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Extracting Urban Sustainability Indicators for Tehran Metropolis by Fuzzy Delphi Method

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Abstract: The concept of urban sustainability emerged after considering to sustainable development in the two past decades. Nowadays, many cities and metropolis are increasingly recognizing the need to follow this concept base on the sustainability agenda. One of the important ways of incorporating the concerns of sustainability into local urban planning programs is to develop and use indicators of urban sustainability. Urban sustainability assessment is a tool to evaluate urban development plans for achieving sustainable city for purpose of social, economic, environmental and institutional sustainability which can help urban planners, designer and managers to take and make a decision for urban development in the future. However, lake of a set of urban sustainability indicator has made urban planners and managers not have any vision to pursue urban sustainability in Tehran Metropolis. Therefore, the main purpose of this paper is to review the existing major urban sustainability indicators and to extract a set of urban sustainability indicators for Tehran Metropolis by the Fuzzy Delphi Method (FDM). Finally, 25 urban sustainability indicators are extracted under four dimensions such as social, economic, environmental and institutional sustainability.

Key words: Urban sustainability · Fuzzy Delphi Method · Urban sustainability indicators · Tehran Metropolis

INTRODUCTION

The concept of sustainable development is a complex issue as it concerns different goals, content types, approaches, aspirations and desires. Sustainability needs to be measured if sustainable development is going to be analyzed and conducted based on a decision making process [1] Urban decision makers use sustainability assessment as a tool that can help them decide what to do to make the society more sustainable. Through measuring and assessing the progress of sustainability, more information will be elicited so that urban planners are able to evaluate their plans and programs; therefore, it is considered as a fundamental element for achieving sustainability.

Moreover, determining of urban sustainability indicators has become a significant issue in Tehran. Hence, the aim of this paper is to define the urban sustainability, the principles and components of urban sustainability, the preliminary urban sustainability indicators based on literature review and finally, extracting a set of urban sustainability indicators for Tehran Metropolis by FDM. Therefore, this paper first constructs a set of preliminary indicators of urban sustainability obtained from literature review and analysis of international and local urban sustainability indicators. Then Fuzzy Delphi Method (FDM) and experts' opinion have been utilized to identify a set of urban sustainability indicators for Tehran Metropolis.

Based on FDM steps, the questionnaire examination of urban sustainability indicators has been conducted. The questionnaire was designed in a fuzzy linguistic scale and every expert rated the importance of each indicator in the form of a triangular fuzzy number and then they were applied as a consensus in determining the importance of urban sustainability in Tehran Metropolis. The chosen experts are expert in the fields related to this research with the experience of academic, governmental and consulting engineers sectors.

Literature Review and Conceptual Framework: In this section, first of all the definition and concept of urban sustainability, four dimension of urban sustainability such as social,economic, environmental and institutional sustainability are discussed in order to set-up the conceptual framework. Then the backgrounds of sustainability indicators are analyzed and the preliminary indicators are obtained.

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Definition of Sustainability and Urban Sustainability: The meaning of sustainability and urban sustainability concepts help to first compare them to sustainable development. However, the meanings of these two concepts are so close that cause interchangeable use of them within the literature [2]. Then, to distinguishing them, we should consider sustainability concept as a desirable state or set of conditions that continues over time. On the other way round, the word 'development' in the sustainable development concept suggests a procedure by which sustainability would be achieved. Some of the main features of urban sustainability which are frequently mentioned in the literature are "…intergenerational equity (including social equity, geographical equity and equity in governance), protection of the natural environment (living within its carrying capacity), minimal use of non-renewable resources, economic vitality and diversity, community self-reliance, individual wellbeing and satisfaction of basic human needs". However, there is no unique definition for urban sustainability since various communities are likely to develop different conceptualizations of urban sustainability based on their current economic, environmental, social and institutional conditions.

The most popular notion of sustainability has been declared by the Brundtland Report: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [3]. Moreover, sustainability is a normative notion that clarifies how human-beings should act towards nature and their responsibly towards one another and future generations [4]. Berkes and Folke [5] defined sustainability as a procedure in socio-ecological relations comprising ecological, social and economic dimensions, that suggests not challenging ecological thresholds on chronological and spatial scales which would negatively disturb ecological and social systems.

Urban sustainability is considered to be an appropriate state or set of urban circumstances that continues overtime. It is usually associated with issues such as; "… inter as well as intra generational equity, protection of the natural environment, minimal use of non-renewable resources, economic vitality and diversity, community self-reliance, individual wellbeing and satisfaction of basic human needs" [6].

The complexity and diversity of the effects on urban sustainability has caused the lack of a vibrant answer to 'How can a city be sustainable?' this complexity also can disturb the endeavours to overcome the multi-sidedness, multi-variation, multi-explainability, multi-layeredness, multi-dimensionality, multi-exportability and multi-measurability of the urban sustainability issue [7]. In summary, there are so many different definitions for urban sustainability but in general, the sustainability issue at the urban level would be an opportunity since it can clearly showcase the four dimensions of sustainability such as social, economic, environmental and institutional sustainability in the city in an integrated manner.

Conceptual Framework: The framework chosen defines the context within which the information is viewed and influences which indicators are used and how they are organized. Given the fact that measuring sustainability is coupled with sustainability indicators, there is a need for urban sustainability indicator systems that reflect the integration of relevant dimensions in terms of social, economic, environmental and institutional indicators. Six general frameworks have been identified which can be used to develop sustainability indicators via integrating conceptual framework which are namely: domain-based frameworks, goal-based frameworks, sectoral frameworks, issue frameworks, causal frameworks and combination frameworks. In this paper, domain–based framework, goal–based framework and issue-based framework are combined together to tackle disadvantages of above mentioned individual frameworks; and also to present a new framework aiming to be suitable for establishing urban sustainability indicators. However, the main dimensions in this paper are: environmental sustainability, social sustainability, economical sustainability and institutional sustainability which have been methodically derived from the theories and literature of urban planning, urban design and urban development within sustainable development and urban sustainability frameworks.

Environmental Sustainability: The term of environmental sustainability was possibly first created at the World Bank; the term was entitled 'environmentally responsible development. Afterwards, environmentally sustainable development was emerged. Sutton [8] defined environmental sustainability to be the skill of preserving the valued assets in the physical environment. Regarding Goodland's statement; human welfare would be improved via environmental sustainability since it protects the raw materials sources while ensuring that the capacity for human wastes is not overdone, which avoid harms to the human. Goodland's theory on environmental sustainability is in line with the resource-limited ecological-economic framework of limits to growth.

The OECD Environmental Strategy for the First Decade of the 21st Century has been one of the major contributions to the concept of environmental sustainability. Four specific criteria for environmental sustainability have been defined by this strategy which are; "… (i) Regeneration (renewable resources shall be used efficiently and their use shall not be permitted to exceed their long-term rates of natural regeneration), (ii) Substitutability (non-renewable resources shall be used efficiently and their use limited to levels which can be offset by substitution with renewable resources or other forms of capital), (iii) Assimilation (releases of hazardous or polluting substances into the environment shall not exceed their assimilative capacity) and (iv) Avoiding Irreversibility."

A definition of environmental sustainability puts quantitative, physical restrictions, as it implies limiting the supply of energy and raw materials to reserves of natural resources and to the capacity of the environment to absorb and recycle the waste that is generated [9]. Environmental sustainability is correctly defined by focusing on its bio geophysical aspects which means maintaining or improving the integrity of the Earth's life supporting systems [10]. Finally, environmental sustainability was indicated by biodegradation, changes in the ecosystem and life cycles, depletion of energy and resources, transportation and so on.

Economic Sustainability: Economic sustainability is the second dimension of urban sustainability. A healthy local economy provides meaningful jobs for all social and age groups and thus contributes to social inclusion and integration. The local economy also needs to be resilient enough to withstand the stresses and changes associated with a competitive marketplace; communities with a dependence on few industrial sectors are more brittle than those with a wide array of employment opportunities. Whether a local economy is likely to grow, create good jobs and become more resilient is partially dependent on the social capital present in the community, i.e., the stock of knowledge and skills found among residents. According to many experts, social capital is becoming more important that the traditional attractors such as access to natural resources, low taxes, cheap labour and good infrastructure in luring new firms to the community. This is especially true of those footloose corporations and institutions such as high-tech operations, advanced educational institutions and cultural centres that specialize in the production or use of culture or knowledge. These entities depend far more on the availability of talented employees than on physical resource inputs [11].

Economic sustainability refers to capital and employment whereby a balance between supply and demand would be facilitated to smooth the progress of economic development without harm to the environment [12]. Enabling an urban economic situation that is productive, stable and innovative in formulating a sustainable urban dynamism as a contributor of job opportunities. Objective of sustainable economy indicator, to eradicate urban poverty, increase urban productivity and increase job opportunities to encourage perpetual urban growth.

Social Sustainability: Defining social sustainability as an independent dimension of urban sustainability has not got so much attention in the literature since there is still no agreement on what criteria and viewpoints should be accepted for defining social sustainability. Littig and Griebler (2005) define social sustainability from a sociological standpoint as a quality of societies. Moreover, "… it signifies the nature-society relationships, mediated by work, as well as relationships within the society. Social sustainability is given, if work within a society and the related institutional arrangements satisfy an extended set of human needs and are shaped in a way that nature and its reproductive capabilities are preserved over a long period of time and the normative claims of social justice, human dignity and participation are fulfilled".

Polese and Stren [13] have provided a definition of social sustainability with a special focus on urban environments as "… Development that is compatible with harmonious evolution of civil society, fostering an environment conductive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population" which puts emphasis on the economic and social dimensions of sustainability, stressing the conflicts between economic efficiency and social break-up central to the term of sustainable development. They also recognised and highlighted the significance of the physical environment within the urban sustainability area such as; housing, urban design and public spaces.

Bramley *et al* [14] has recognised the two predominant notions of social sustainability including 'social equity' and the 'sustainability of community'

where the first one is connected with social justice urging the fair delivery of resources in society facilitating just access to jobs, housing and local services. The second one is linked with the ongoing feasibility of society as a communal body. They also stated that sustainability is subject to several characteristics of the society which keep and advance the properties of social capital nourishing trust, collaborative and harmonious comportment required to reinforce civil society which include; "… (i) interactions in the community/social networks; (ii) community participation; (iii) sense of place; (iv) community stability; (v) security (crime)."

Finally, Edward.A (2012) believes that social sustainability can be defined in terms of the amount and impacts to "… which this sense of loss of culture and self-sufficiency can be remunerated as part of the social sustainability assessment process; albeit beyond material comfort needs so as to compensate for the non-material aspects associated with sense of loss of social well-being and culture."

Nowadays, social sustainability has been considered as a significant element of urban sustainability demanding to recognise the issues related to this concept. The European Panel on Sustainable Development (EPSD, 2004) revealed that the Lisbon European Council launched the notion of social dimension as an integral portion of the sustainable development model for the first time in 2000 which enclosed four key dimensions of social sustainability comprising; "… a commitment to enhance education, especially in relation to the new skills required for the 'knowledge-intensive' economy; revamping employment policy so as to create 'more and better jobs'; modernising social protection to accommodate the many challenges faced by welfare states, to 'make work pay' and to promote equality; and the development of a strategy to counter poverty and social exclusion by promoting social inclusion".

Social sustainability from a more specific point of view is linked with "… the personal and societal assets, rules and processes that empower individuals and communities to participate in the long term and fair achievement of adequate and economically achievable standards of life based on self-expressed needs and aspirations within the physical boundaries of places and the planet as a whole." However, from a more practical point of view, social sustainability stalks from "… improvements in thematic areas of the social realm of individuals and societies, ranging from capacity building and skills development to environmental and spatial inequalities" which shows how social sustainability merges traditional social goals and policy matters like; health and equity with some concerns linked with participation, requirements, social capital, the environment, the economy, well-being, quality of life and more recently, with the ideas of happiness [15].

Institutional Sustainability: Since the Earth Summit, countries have made considerable progress in establishing an appropriate institutional framework for the implementation of sustainable development. This includes the development of national strategies aimed at integrating social, economic and environmental priorities; and action to sign, ratify and initiate the implementation of global agreements.

The ability of a country to progress towards sustainable development is largely determined by the capacity of its people and institutions. Capacity can be measured by a country's human, scientific, technological, organizational, institutional and resource capabilities. Institutional capacity enhances participatory planning, implementation and monitoring related to sustainable development. An increase in capacity improves community skills and abilities to address crucial questions, evaluate policy options and implementation approaches and appreciate constraints and limitations.

Communication systems, information access and availability, the support for science and technology and the prevention and mitigation of natural disasters are all elements of a country's institutional capacity. Although a wealth of data and information may be available, finding the appropriate scale and currency of information is not always easy. This situation is exacerbated in the absence of modern communications infrastructure. In this context, the Commission on Sustainable Development reported little progress in making national telecommunications systems responsive to the growing demand for electronic information. The innovative delivery of health and educational services, the alleviation of the isolation of remote areas and the reduction of the need for transportation represent some of the tangible sustainable development benefits that can be derived from up-to-date electronic and telecommunications systems.

Institutional capacity is a significant means for facilitating movement towards sustainable development, but it is difficult to assess appropriately with a limited number of core indicators. The indicators selected for this theme measure information access, communications infrastructure, science and technology and natural

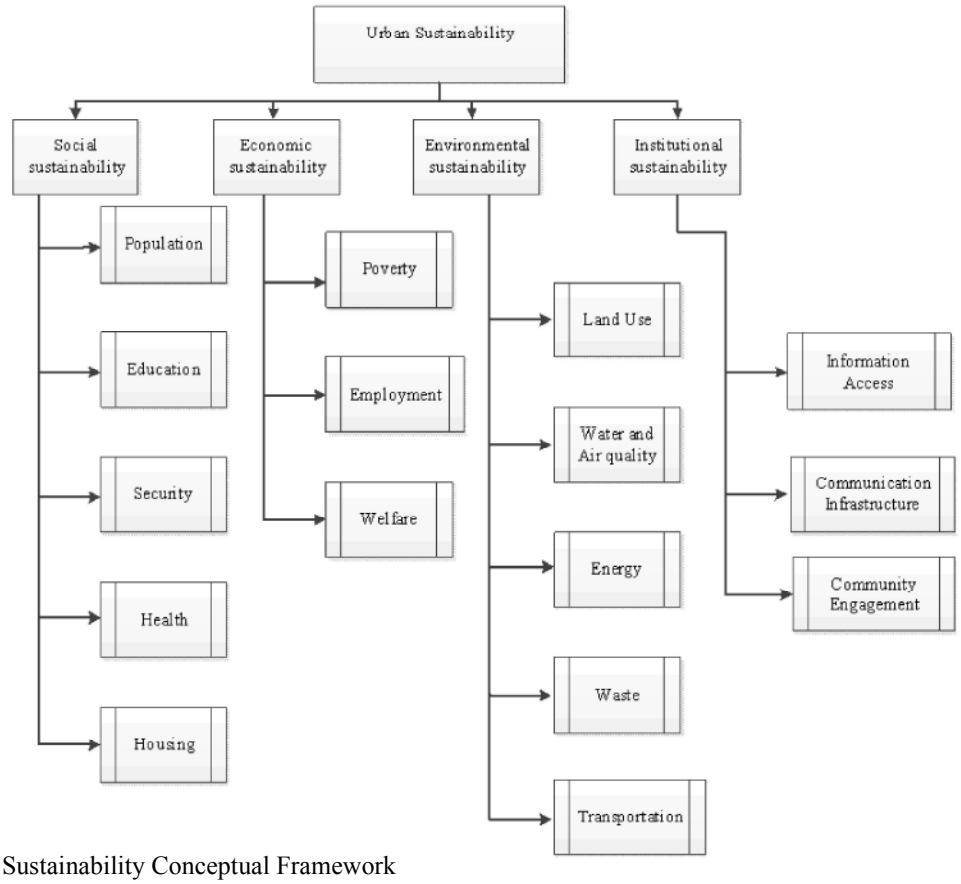

Fig. 1: Urban Sustainability Conceptual Framework

disaster preparedness and response. These represented important issues for the testing countries. The four indicators are primarily national in scope and suitable for measuring trends. They are structured to be useful to both developing and developed countries [16].

Finally, based on the detailed literature on the concept of sustainable development and in particular urban sustainability and also according to the delicate analysis on the urban sustainability principles and dimensions, the theoretical framework of this paper has been designed and illustrated in Fig 1 in the following.

Background

Urban Sustainability Indicators: There have been significant changes in the world since the relatively recent review of indicator use for measuring and reporting sustainability. Nowadays, urban sustainability indicators have been progressively recognized as a powerful tool which can help urban planners, designers and managers to take and make a decision for urban development in the future.

Background of Urban Sustainability Indicators: To get urban sustainability indicators for this study, some attempts have been made to develop a set of indicators with the aim of measuring and assessing progress towards sustainability at the local level of Tehran Metropolis. Based upon literature and four components of economic development, environmental protection, social equity and institutional improvement, the existing indicators deal with a variety of aspects of cities like population, housing, economy, land use, environment, transportation, education, safety, health, community engagement and so on. Most of the existing indicators have been listed in Table 1.

Determining of Preliminary Urban Sustainability Indicators: This study uses 42 preliminary urban sustainability indicators which are determined from 25 listed indicators. They include 15 indicators that are related to the social aspects, 18 indicators within the environmental aspects, 5 indicators in the economic aspects and 4 indicators related to institutional aspects. The preliminary urban sustainability indicators used in this study are presented in Table 2.

Table 1: Background of Urban Sustainability Indicators

Indicator Listed by:	Social	Economical	Environmental	Institutional
UNCHS (1997)	8 Categories, 46 indicator			
Habitat (1993)	15	4	10	5
Sustainable Indicator South Korea (2006)	Mix 38			
Central Texas Sustainable Indicator (2004)	21	9	12	-
United Nations Department of Economic and Social Affairs(1999)	19	14	19	6
European foundation for improvement (1998)	7	3	8	-
Hart's Indicator	11	20	49	1
Organization for Economic Co-Operation and Development (OECD, 2000)	Socio-Economic 15	18	-	
Seattle Indicator project (1998)	16	10	14	-
Taiwan experience	6 Categories, 52 indicator			
Malaysian Urban Network Index (MURNI net,2003	11 Categories, 56 indicator			
Community University Institute for Social Research (2005)	11 Categories, 72 indicator			
Daneshpour.Z, (2008)for Tehran	-	-	5	-
Seifollahi, *et al*.(2011) to evaluate environmental quality of Tehran			12	

Table 2: Preliminary Urban Sustainability Indicators

Urban Sustainability Indicators		
Dimension	Criteria	Indicator
Social(D1)	Demography(C1)	Population Growth Rate(I1)
		Population Density(I2)
		Urbanization Rate(I3)
	Education(C2)	Number of Students per Teacher(I4)
		Number of Students per Classroom (I5)
		Literacy Rate(I6)
	Health(C3)	Life Expectancy at Birth(I7)
		Availability of Medical Services per 1,000 Inhabitants(I8)
		Doctors and Population Ratio(I9)
		Percent of Population with Access to Safe Drinking Water(I10)
	Security(C4)	Number of Crimes per 10,000 Population(I11)
	Housing(C5)	Home Ownership Rate(I12)
		Average Household Size(I13)
		Number of Housing Units per 100 Households(I14)
		Population of Formal and Informal Settlements(I15)
Economic(D2)	Poverty(C6)	Percent of Population Living below Poverty Line(I16)
		Ginni Index of Income Inequality(I17)
	Employment(C7)	Unemployment Rate(I18)
		Employment Growth Rate(I19)
	Welfare(C8)	Average of Housing Price and Income Ratio(I20)
Environmental(D3)	Land Use(C9)	Public Park Acreage per Capita(I21)
		Urban Green Space(I22)
		Percentage of Agriculture Area(I23)
		Percentage of Greenbelt Area(I24)
		Percent of New Houses Built on Previously Developed Lands(I25)
		Ratio of Built-up and Un-built Areas(I26)
		Annual Growth of Built-up Areas(I27)
		Loss of Natural and Agricultural Land(I28)
	Water and Air Quality(C10)	Groundwater and Drinking Water Pollution(I29)
		Water Consumption per Capita (I30)
		Days when air Pollution is Moderate or Higher(I31)
	Waste(C11)	Waste Generation per Capita(I32)
		Waste Recycling Rate(I33)
		Percentage of Residential units Serviced by centralized Sewerage(I34)
		Industrial Zones having Waste and Water Treatment Systems(I35)
	Energy(C12)	Energy Consumption per Household(I36)
	Transportation(C13)	Percentage of public bus users (I37)
		Use of private car (I38)
Institutional(D4)	Information(C14) Access	Number of Internet Subscribers per 1,000 Inhabitants(I39)
	Communication Infrastructure(C15)	Main Telephone Lines per 1000 Inhabitants(I40)
	Community Engagement(C16)	Number of NGOs per 10,000 Inhabitants(I41)
		Voter Participation Rate(I42)

MATERIALS AND METHODS

Fuzzy Delphi Method (FDM): The traditional Delphi Method has got some disadvantages such as; low consistency of experts' opinions, high enforcing cost and modification of experts' individual opinions in order to achieve consistent general opinions. Scholars from different parts of the world attempted to find new methods to solve the problem of fuzziness in expert consensus resulting from group decision making; therefore, Murray *et al*. [17] suggested the application of Fuzzy Theory to the Delphi Method to eradicate the vagueness and ambiguity of Delphi Method with semantic variables while membership degree was used to establish the membership function of each participant. Klir and Folger [18] recommended a mean normalization mode while Ishikawa *et al*. [19] presented the fuzzy theory into the Delphi Method and developed the Maximum-Minimum Method together with Cumulative Frequency Distribution and Fuzzy Scoring to assemble the experts' opinions into fuzzy numbers.

The experts' prediction interval value was then used to derive the fuzzy numbers; resulting in the Fuzzy Delphi Method.But the limitation of this method was only appropriate to forecast time series data. Hsu and Chen [20] proposed 'Fuzzy Similarity Aggregation Method', this method is based on the similarity function where similarities between experts were collated and fuzzy numbers allocated directly to each expert to indicate the agreement degree between them. Besides, Hsu *et al*. [21] utilized triangular fuzzy number to incorporate experts' opinons and launch the Fuzzy Delphi Method.

To develop the statistically balanced impact and avoid the extreme values effect, the max and min values of experts' opinions were considered as the two terminal points of triangular fuzzy numbers and the geometric mean was taken as the membership degree of triangular fuzzy numbers. One advantage of this method is easiness by which all the experts' opinions could be incorporated into one investigation; additionally, the method would create a better impact of indicators selection. Previous researches have applied three fuzzy membership functions

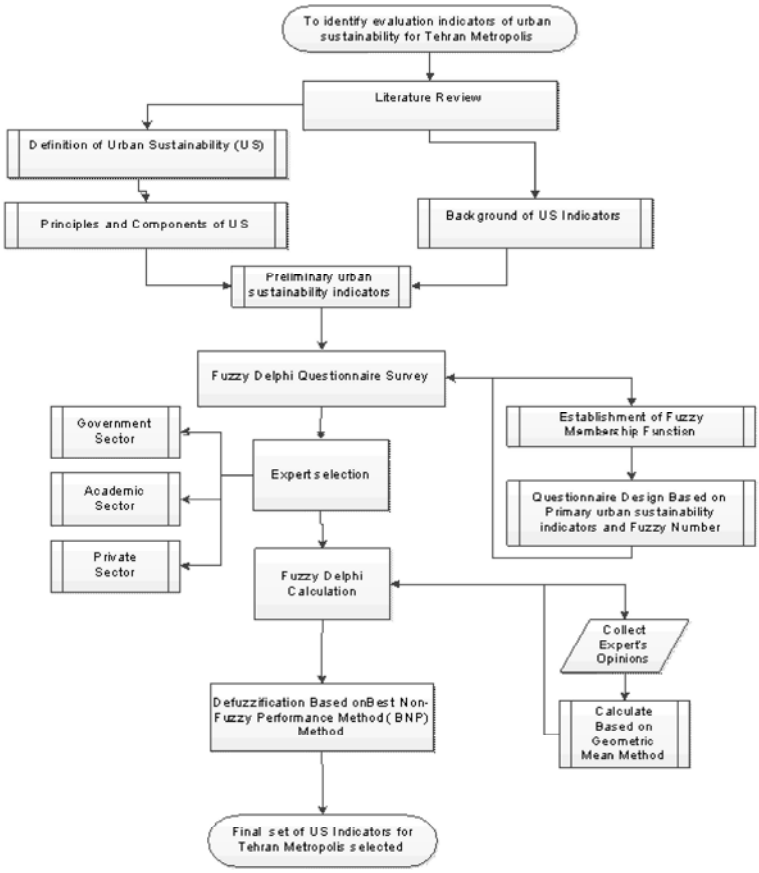

Fig. 2: FDM framework

such as; 'triangular fuzzy number', 'trapezoidal fuzzy number' and 'Gaussian fuzzy number'; however, according to Hsu *et al* [21] triangular fuzzy number has been selected for this study. All in all, the Fuzzy Delphi Method suggested by Hsu *et al* [21], Geometric Mean Method, has been implemented in the process of the selection of urban sustainability indicators because this method saves time and cost necessary for collecting experts' opinions which would also be sufficiently expressed without being biased since it needs only a small number of samples; finally, the derived results are objective and reasonable [21].

The process of FDM: The processes of FDM are listed in Figure 2 in the following. As it can be seen in this figure the first step is to extract preliminary sustainability indicators based on the literature review, the second step includes the application of Fuzzy Delphi Method (FDM) by designing questionnaire survey for a panel of experts within different sectors. The next step is to collect experts' opinions based on the fuzzy membership function and to calculate their opinions by Geometric Mean Method. The final step is to defuzzify the calculated result by means of Best Non-fuzzy Performance Method (BNP) then selecting final set of Urban Sustainability indicators for Tehran Metropolis (Fig.2).

RESULT AND DISCUSSION

Extracting the Urban Sustainability Indicators for Tehran Metropolis by FDM: Extracting the urban sustainability indicators for evaluating the urban sustainability of Tehran Metropolis is based on the application of Fuzzy Delphi Method (FDM) in detailed steps is presented in the following.

Questionnaire Design: An expert questionnaire is a suitable tool for collecting data in a Delphi survey when it is impossible to interviewee individuals in terms of time and group arrangement [22]. Five experts in related areas were invited to take the pre-test with the aim of modifying unclear questions in the preliminary questionnaire; at the end, according to their suitability with the aim of enhancing the merging of survey questions; some questions indicator title were added, edited, or eliminated.

The designed questionnaire was separated into two sections. The first section was about the basic data and the experts' information while in the second section the respondents were asked to rate the importance of urban sustainability indicators using a 1–9 point scale that a higher point indicated a higher importance. To find the assessment score of each determined indicator given by each expert using linguistic variables, first of all, the questionnaire was designed in a 9-point fuzzy linguistic variable such as: 'absolutely unimportant', 'very unimportant', 'quite unimportant', 'unimportant', 'fair', 'important', 'quite important', 'very important' and 'absolutely important'.

Selection of Experts: Some researchers believe that careful selection of the panel of experts would lead to the success of Delphi method [23]. Cabaniss [24] proposed that "… an expert may be defined as someone with special skills or knowledge evidenced by leadership in professional organizations, holding office in professional organizations, presenter at national conventions and publisher in recognized journals". This study concentrates on the extraction of urban sustainability indicators for assessment of urban sustainability in Tehran. Thus the experts chosen are the professionals in the fields related to our research with the experience of the academic, governmental and consulting engineers sectors. Also, they should have at least working experience related to urban sustainability or sustainable development. In general, the number of experts are from three to fifteen [25] but the questionnaires of this study were sent out to 30 experts because urban sustainability is a complex and multidimensional concept.

Collecting Experts' Opinions: The selected experts were asked to respond the questionnaire survey; therefore, they gave a relative importance to each collected indicator with regard to four social, economic, environmental and institutional dimensions as the evaluation indicators of urban sustainability indicators. As mentioned above, urban sustainability is a complex and multi-dimensional concept, therefore, 30 survey questionnaires were sent to the experts, but receiving 21 effective responses. At the first step of the survey, the valid response rate was 83%. Regarding collecting data, SPSS18 were used for analyzing and extracting the appropriate indicators. In the second step, reliability and validity of the indicators were confirmed. Cronbatch' α reliability and content validity were utilized to assess the reliability and validity of the constructs. All of the Cronbatch' α values, ranging from a low of 0.757 to a high of 0.930 exceeded the recommended value of 0.70.

Set up Triangular Fuzzy Numbers: Organize experts' opinions collected from questionnaires into estimation and generate the triangular fuzzy number TFN_A as:

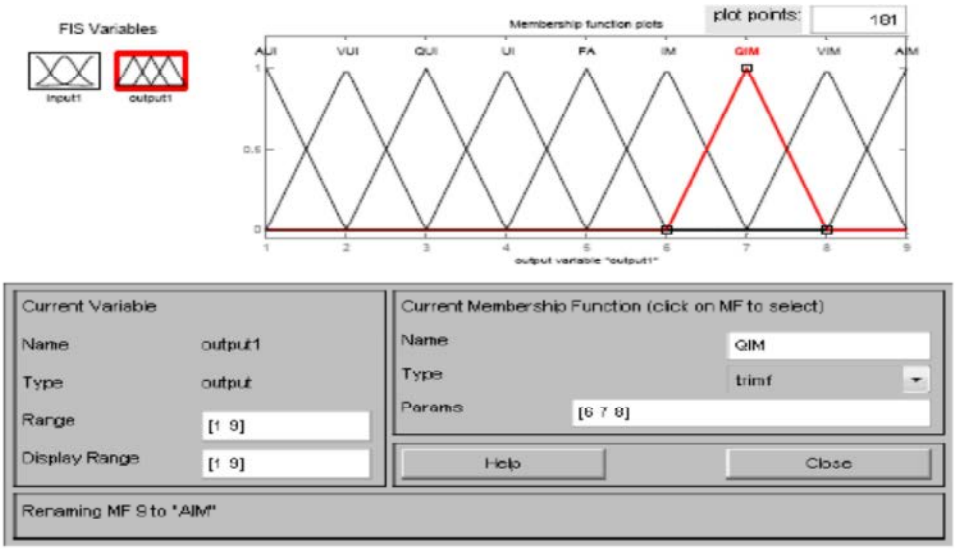

Fig 3: Triangular Fuzzy Membership Function for Urban Sustainability Indicators

$$TFN_A = (L_A, M_A, U_A) \quad (1)$$

$$L_A = Min(X_{Ai}) \quad (2)$$

$$M_A = \sqrt[n]{\prod_{i=1}^{n} X\ A_i} \quad (3)$$

that i denotes the ithe expert, I=1,2,….,n

$$U_A = Max(X_{Ai}) \quad (4)$$

Where X_{Ai} indicates the appraisal value of the ithe expert for indicator A; L_A indicates the minimum of all the experts' apprasial value for indicator A; M_A indicates the geometric mean of all the experts' apprasial value for indicator A and U_A indicates the maximum of all the experts' apprasial value for indicator A.

FDM Calculation and Defuzzification: In this study, the geometric means of each indicator's triangular fuzzy number was employed to designate the consensus of the expert group on the indicator's evaluation value; hence, the impact of extreme values could be avoided. Since the importance of all evaluation indicators are fuzzy number values, therefore it is essential to calculate a non-fuzzy value by defuzzification method. In other words, defuzzification is a technique to convert the fuzzy number into crisp real numbers. There are several available methods to serve this purpose that include: Mean-of-Maximum Method, Centroid Method (the Best Non-fuzzy Performance (BNP)), Simple Centre of Gravity Method [26] and α-Cut Method. In his study, based on the Centroid Method, its simplicity and the point that it does not require an analyst's personal judgment, the Best Non-fuzzy Performance (BNP) was utilized to defuzzification. Through the following formulas, the defuzzified value of fuzzy number can be obtained. This study utilized MATLAB software to calculate FDM and defuzzification.

$$BNP = \frac{(Ui - Li) + (Mi - Li)}{3} + Li \quad (5)$$

Screen Urban Sustainability Indicators: Finally, appropriate indicators could be screened out from abundant indicators by setting the threshold BNP. The principle of screening is as the following:

- If BNPi=7, then this US indicator is accepted.
- If BNPi<7, then this performance indicator is rejected.

Selection of Final Urban Sustainability Indicators: This stage included three sections. Firstly, it listed four main dimensions and 42 indicators as the preliminary urban sustainability indicators according which FDM questionnaire survey are designed. The second section is sending questionnaire for our experts from the academic, governmental and private, consulting engineers, sectors in Tehran. In the third section and finally, the experts' opinions in FDM questionnaires are transformed to triangular fuzzy numbers and defuzzified values can be figured out after computation. This stage adopted elements with threshold above 7 and the assessment indicators with threshold below 7 are rejected [27]. The important USIs after screening are listed in Table 3.

Table 3: The important sustainability indicators based on their deuzzified values

Dimension	Indicators	Defuzzified
Social	Population growth rate	7.01
	Population density	7.03
	Literacy rate	7
	Availability of medical services per 1,000 inhabitants	7.42
	Percent of population with access to safe water	8.06
	Number of crimes per 10,000 population	7.5
	Number of housing units per 100 households	7.04
	Population of informal Settlements	8.03
Economical	Percent of population living below poverty line	7.61
	Unemployment rate	7.26
	Employment growth rate	7.54
Environmental	Urban green space per capita	7.03
	Loss of natural and agricultural land	7.27
	Groundwater and drinking water pollution	7.79
	Water consumption per capita	7.39
	Number of days with moderate or higher air pollution	7.79
	Waste generation per capita	7.61
	Waste recycling rate	7.57
	Percentage of residential units serviced by centralized sewerage	7.61
	Industrial zones having waste and water treatment systems	7.56
	Energy consumption per household	7.6
	Percentage of public bus users	7.53
	Percentage of private car users	7.53
Institutional	Number of internet subscribers per 1,000 inhabitants	7.02
	Main Telephone Lines per 1000 Inhabitants	7.14

CONCLUSION

When sustainable development is introduced as a global issue, urban authorities want to know how much they away from or achieve to urban sustainability. Thus, establishing a set of urban sustainability indicators will be necessary and can help them to evaluate their situation. This study utilized Fuzzy Delphi Method to identify a set of urban sustainability indicators and to determine their importance for Tehran Metropolis.

The research findings showed that Percent of population with access to safe water, Population of informal Settlements, Number of crimes per 10,000 populations and Availability of medical services per 1,000 inhabitants in social dimension are the indicators most valued while Literacy rate, Population growth rate, Number of housing units per 100 households, Population density have the fewest. In the Economic dimension, the most important indicators are Percent of population living below poverty line, Employment growth rate and the less important is unemployment rate. In environment dimension, the Groundwater and drinking water pollution,Number of days with moderate or higher air pollution, Waste generation per capita, Percentage of private car users, Waste recycling rate, Industrial zones having waste and water treatment systems, Energy consumption per household, Percentage of public bus users, Percentage of residential units serviced by centralized sewerage have the most key indicators selected while Urban green space per capita, Loss of natural and agricultural land, Water consumption per capita have the fewest. In the institutional dimension, Main Telephone Lines per 1000 Inhabitants, Number of internet subscribers per 1,000 inhabitants are the most important indicators.

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